

## Original Article

# A qualitative study of blood glucose and side effect self-management among patients with type 2 diabetes undergoing chemotherapy for cancer



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## ABSTRACT

**Objective:** This study aimed to identify the process by which patients with type 2 diabetes who are undergoing chemotherapy for cancer personally manage their blood glucose levels and side effects.

**Methods:** Semi-structured interviews were conducted with 16 patients with cancer who had completed chemotherapy while taking hypoglycemic drugs. The interview data were analyzed using the modified grounded theory approach proposed by Kinoshita.

**Results:** Self-management comprised balancing the management of blood glucose levels and side effects according to physical condition. After commencing chemotherapy, participants experienced confusion regarding the side effects and hyperglycemia they have not previously experienced, started struggling with side effects while paying attention to blood glucose fluctuations, experienced simplification of convalescence based on the diabetes experience, and used trial and error to cope with side effects. When participants learned to understand the changes in blood glucose fluctuations and the pattern of physical recovery, they completed chemotherapy by adjusting their physical condition to the treatment by varying self-control.

**Conclusions:** Healthcare providers need to assist patients receiving chemotherapy to promote self-management of both blood glucose levels and side effects of the chemotherapy, depending on their physical condition. It is essential that patients with type 2 diabetes who are undergoing chemotherapy achieve the ability to self-monitor their blood glucose levels and side effects.

## Introduction

The numbers of patients with diabetes and those with cancer increase worldwide annually.<sup>1,2</sup> In Japan, the number of patients with diabetes who are co-diagnosed with cancer has recently increased.<sup>3</sup> Thus, the number of patients with diabetes who are undergoing chemotherapy is expected to increase.

When patients with diabetes undergo chemotherapy, they tend to have a higher mortality rate and more severe side effects than patients without diabetes,<sup>4–8</sup> owing to diabetes-related glycemic abnormalities.<sup>9,10</sup> Therefore, it is critical for patients with diabetes to manage blood glucose fluctuations and side effects during chemotherapy because these factors can drastically affect their overall quality of life. However, self-management of type 2 diabetes, which accounts for 90% of all cases of diabetes, is challenging,<sup>1</sup> and even more so when the patient is diagnosed with and is being treated for cancer. This is because self-management of type 2 diabetes involves self-improvement of lifestyle habits, including diet and exercise.<sup>11</sup> Patients with cancer also need to manage their disease; however, the main focus of self-management of

cancer is on the side effects of the treatment, physical changes, and psychosocial effects.<sup>12</sup> Considering these, self-management of diabetes alone and self-management of diabetes with cancer must be approached separately.

Patients using hypoglycemic drugs are less likely to routinely self-monitor their blood glucose levels because the effectiveness of self-monitoring of the blood glucose level has not been fully established.<sup>13,14</sup> During chemotherapy, hyperglycemia is induced through the administration of steroids to assist patients with monitoring their blood glucose levels.<sup>15</sup> However, it is difficult for the patients to immediately identify and respond to these changes in blood glucose levels. Moreover, chemotherapy is associated with several complex side effects,<sup>16,17</sup> which may further confuse the patients.<sup>18,19</sup> Hence, it is important to assist patients with self-management, specifically patients with diabetes who are undergoing chemotherapy while taking hypoglycemic drugs.

Previous studies have provided information on the blood glucose fluctuations and side effects experienced by patients with diabetes who were diagnosed with cancer and were undergoing chemotherapy.<sup>20–22</sup> However, the authors of these studies did not indicate how the patients

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managed their blood glucose fluctuations and side effects. The support measures for these patients highlighted in existing studies are limited to the introduction of collaborative arrangements among healthcare providers and evaluation of how to manage the support measures using simulated cases.<sup>23,24</sup> Further, it has been reported that medical professionals who specialize in the treatment of cancer or diabetes are not fully familiar with the scope of the expertise of other healthcare professionals; thus, the exchange of patient information between teams is insufficient.<sup>25–28</sup> Therefore, empirical studies on self-management procedures for patients with type 2 diabetes who are undergoing chemotherapy are essential. In addition, it is important to evaluate the support measures for these patients from the perspectives of both diabetes and cancer. Thus, the aim of this study is to identify the process adopted by patients with type 2 diabetes and cancer in self-managing their blood glucose levels and the accompanying chemotherapy-related side effects upon the simultaneous administration of chemotherapeutic and hypoglycemic drugs.

## Methods

### Definition of terms

Self-management of diabetes while undergoing chemotherapy was defined as the adoption of self-care by patients with diabetes for the prevention of complications and stabilization of their blood glucose levels, which fluctuate due to chemotherapy, and the introduction of coping methods for countering the side effects of chemotherapy on daily life.

### Design

This was a qualitative descriptive study conducted using the modified grounded theory approach (M-GTA) proposed by Kinoshita.<sup>29</sup> The M-GTA is a research method that involves the reorganization of methods of analysis based on the GTA developed by Glaser and Strauss.<sup>30</sup> The M-GTA is applicable to research that focuses on the process-related characteristics of phenomena.<sup>29</sup> The M-GTA was deemed appropriate for the present study as it deals with the procedures involved in the self-management process adopted by patients with diabetes who are diagnosed with cancer and are undergoing chemotherapy, from the start of treatment until completion.

### Participants

The participants were patients with type 2 diabetes who were diagnosed with cancer and had completed chemotherapy while taking hypoglycemic drugs. The inclusion criteria were as follows: (1) receipt of adjuvant chemotherapy for the first time; (2) an anticancer drug regimen that included steroids; (3) completion of the first chemotherapy treatment no more than 2 years prior to this study; and (4) a performance status of 0–1. The exclusion criteria were as follows: (1) hematologic cancers that required high doses of steroids and complex chemotherapy regimens; (2) cancers of organs that affect insulin secretion; and (3) stage IV cancers.

### Data collection

Data were collected through semi-structured interviews conducted using an interview guide prepared by the researcher. The participants were requested to talk freely about their efforts to stabilize their blood glucose levels and to deal with the side effects of chemotherapy from the start to completion of treatment. For some cancer types using a combination of two or three regimens as the standard chemotherapy regimen, completion of chemotherapy was defined as the completion of all regimens; and patients were interviewed thereafter. Each interview was conducted in a private room and lasted approximately 60 min. The interviews were conducted at

outpatient visits during the waiting time. Patient information, including demographic information such as age and sex, diabetes history, history of chemotherapy, blood glucose levels, and side effects, were extracted from medical records with informed patient consent. The data collection period was from August 2021 to August 2022.

### Data analysis

The data obtained during the interviews were analyzed using the M-GTA developed by Kinoshita. The focus of the analysis was patients with type 2 diabetes diagnosed with cancer and having completed chemotherapy while taking hypoglycemic drugs. The goal of the analysis was to establish how the patients managed their blood glucose levels and side effects from the start to completion of chemotherapy.

For the analysis, the author carefully read the transcribed data of one case that provided a content-rich narrative, extracted the parts that fit the aims of the analysis, and generated the identified concepts. A worksheet with definitions, variations (concrete examples), and theoretical notes was created for each generated concept. Regarding the data obtained from the interviews that followed, continuous comparative analyses were conducted using the previously generated concepts. Further, the concepts were repeatedly modified based on the added variations observed in the records of further interviews. It was determined that theoretical saturation in concept generation had been achieved when there were no new variations to be extracted from the “next” interviews. After completion of the analysis of all participant data, the relationships among the concepts were evaluated, categories and core categories were generated, and a result diagram was created. Finally, storylines that explained the result diagram were created.

### Trustworthiness

In this study, Shenton's criteria were used to ensure the trustworthiness of the qualitative research.<sup>31</sup> To increase credibility, the M-GTA, which is suitable for process characteristics research and has a well-established research methodology, was chosen for the analysis. Subsequently, according to the study objectives, the participant selection criteria were set, and four target institutions were selected to collect a wide range of data. The validity of the analysis was enhanced via repeated discussions among several researchers with clinical and qualitative research experience until consensus regarding data analysis was reached. Additionally, the results chart was explained to one participant to ensure that the results were representative of the participant's experience.

Confirmability was ensured by keeping detailed records of the process from data collection to interpretation. To ensure transferability, the study institutions, participant selection criteria, data collection methods, data collection period, and number of participants were described. Dependability was ensured by describing the research process in detail.

## Results

### Overview of participants

Sixteen outpatients from four medical institutions in two regions of Japan participated in this study. The participants had lung ( $n = 7$ ), uterine ( $n = 3$ ), ovarian ( $n = 3$ ), and breast ( $n = 3$ ) cancers. Ten patients had diabetes for  $< 10$  years.

The pre-chemotherapy glycated hemoglobin levels of six patients were  $< 7\%$ . Thirteen patients used insulin during chemotherapy. The chemotherapy regimen of one patient was changed because the patient showed severe symptoms of peripheral neuropathy (Table 1).

All participants had been hospitalized at least once for treatment using anticancer drugs, and their blood glucose levels were measured three or four times a day during hospitalization. The mean blood glucose level of the patients before chemotherapy was  $(155.0 \pm 38.4)$  mg/dL.

**Table 1**  
Participant characteristics.

	Age/ Gender (M: Male, F: Female)	Type of cancer	Stage	Duration of living with diabetes (years)	Diabetes- related complications	HbA1c before chemotherapy (%)	Blood glucose before chemotherapy (mg/dL)	Chemotherapy regimen and total number of cycles	Dose of steroids included in regimen (Prednisolone conversion)	Insulin use during chemotherapy	Blood glucose fluctuations during chemotherapy: maximum/ minimum (mg/ dL)
A	60 s/F	Uterus	IIIC	15	Yes	6.4	128	TC <sup>a</sup> 6 cycles	273.8 mg	Yes	94/353
B	70 s/M	Lung	IIIA	34	Yes	7.8	264	CBDCA + Pem +Pembro <sup>b</sup> 4 cycles	41.2 mg	No	75/428
C	60 s/F	Uterus	IB	10	No	6.8	114	TC <sup>a</sup> 6 cycles	123.8 mg	Yes	84/250
D	70 s/F	Ovarian	IIIC	6	No	6.3	131	TC <sup>a</sup> 6 cycles	123.8 mg	Yes	79/262
E	60 s/F	Breast	I	7	No	8.2	156	AC <sup>c</sup> 4 cycles	211.9 mg	No	93/337
F	50 s/F	Uterus	IB	4	No	8.4	152	TC <sup>a</sup> 6 cycles	123.8 mg	Yes	105/472
G	70 s/F	Ovarian	IC	1	No	6.4	207	TC <sup>a</sup> 2 cycles + DC <sup>d</sup> 4 cycles	TC: 123.8 mg DC: 61.9 mg	Yes	87/319
H	60 s/M	Lung	IIIB	8	No	6.3	115	VP-16+CDDP <sup>e</sup> 4 cycles	41.3 mg	No	102/119
I	70 s/M	Lung	IIIB	21	Yes	Unknown	130	Daily CBDCA + RT <sup>f</sup>	41.3 mg	Yes	126/428
J	60 s/M	Lung	IIIB	27	No	8.8	158	weekly TC + RT	41.3 mg	Yes	62/328
K	60 s/F	Breast	IIA	6	No	7.9	132	EC <sup>g</sup> 4 cycles + PTX <sup>h</sup> 12 cycles	15.6 mg	Yes	80/254
L	70 s/M	Lung	IIB	4	Yes	7.0	130	CDDP + VNR <sup>i</sup> 3 cycles	61.9 mg	No	96/130
M	60 s/M	Lung	IIIA	15	Yes	7.2	159	CDDP + VNR <sup>i</sup> 2 cycles	61.9 mg	Yes	95/322
N	50 s/F	Breast	IIIB	4	No	7.3	164	AC <sup>c</sup> 4 cycles	211.9 mg	Yes	116/229
O	40 s/F	Ovarian	IIB	6	No	6.3	138	TC <sup>a</sup> 6 cycles	123.8 mg	Yes	105/361
P	50 s/M	Lung	IIIA	6	No	7.7	203	CDDP + VNR <sup>i</sup> 4 cycles	211.9 mg	Yes	131/328

<sup>a</sup> TC: Paclitaxel + Carboplatin.

<sup>b</sup> CBDCA + Pem + Pembro: Carboplatin + Pemetrexed Sodium Hydrate + Pembrolizumab.

<sup>c</sup> AC: Doxorubicin Hydrochloride + Cyclophosphamide Hydrate.

<sup>d</sup> DC: Docetaxel + Carboplatin.

<sup>e</sup> VP-16+CDDP: Etoposide + Cisplatin.

<sup>f</sup> dailyCBDCA + RT: Carboplatin + Radiation therapy.

<sup>g</sup> EC: Epirubicin Hydrochloride + Cyclophosphamide Hydrate.

<sup>h</sup> PTX: Paclitaxel.

<sup>i</sup> CDDP + VNR: Cisplatin + Vinorelbine detartrate.

Thirteen participants experienced hyperglycemia (> 250 mg/dL), and one participant experienced a fall due to hypoglycemia (< 70 mg/dL) after receiving anticancer drugs (Table 1). The most common side effects of chemotherapy were anorexia, fatigue, nausea, peripheral neuropathy, and constipation; the severity of the side effects for most participants was Grade 1 as per the Common Terminology Criteria for Adverse Events (CTCAE) (Fig. 1).

*Overview of the results*

Twenty-five concepts were generated from the interview transcripts and summarized into seven categories, six of which involved one core category. The categories are indicated with single quotation marks (‘ ’) hereafter. The storylines that were created based on results of the analysis are described below. The result diagrams that illustrate the storylines are shown in Fig. 2.

*Storylines*

Self-management by patients with diabetes who are diagnosed with cancer and are undergoing chemotherapy is a process of “balancing the management of blood glucose level and chemotherapy-related side effects according to the physical condition.” Participants constantly try to ‘maintain mental balance’ during the self-management process from the start until the completion of chemotherapy.

The structure of this core category shows that after the initiation of

chemotherapy, when participants experience ‘confusion regarding the unprecedented side effects and hyperglycemia,’ they begin to ‘struggle with the side effects while paying attention to blood glucose fluctuations.’ Thereafter, through repeated chemotherapy sessions, participants experience ‘simplification of regimens based on the diabetes experience’ and engage in ‘trial and error to cope with side effects.’ These efforts are adjusted depending on the type and severity of the side effects. Further, as the chemotherapy progresses, the participants start to ‘understand the changes in blood glucose fluctuations and the pattern of physical recovery’ and complete the chemotherapy by ‘adjusting their physical condition to the treatment by exercising self-control in various steps’ in preparation for the next cycle of anticancer drug administration.

*Definitions of categories and concepts*

The definitions of the seven categories are outlined in the sections below. The categories are indicated with single quotation marks (‘ ’), whereas participant variations are indicated in *italics*. Angle brackets (<>) indicate the concept name, whereas supplementary explanations by the researcher are indicated in square brackets ([ ]). The letters in boldface placed after a sentence denote the participant being referred to. The definitions of each concept are outlined in Table 2.

*‘Confusion regarding the unprecedented side effects and hyperglycemia’*

The definition of this category indicates that the participants were confused regarding how to cope when the side effects of the treatment

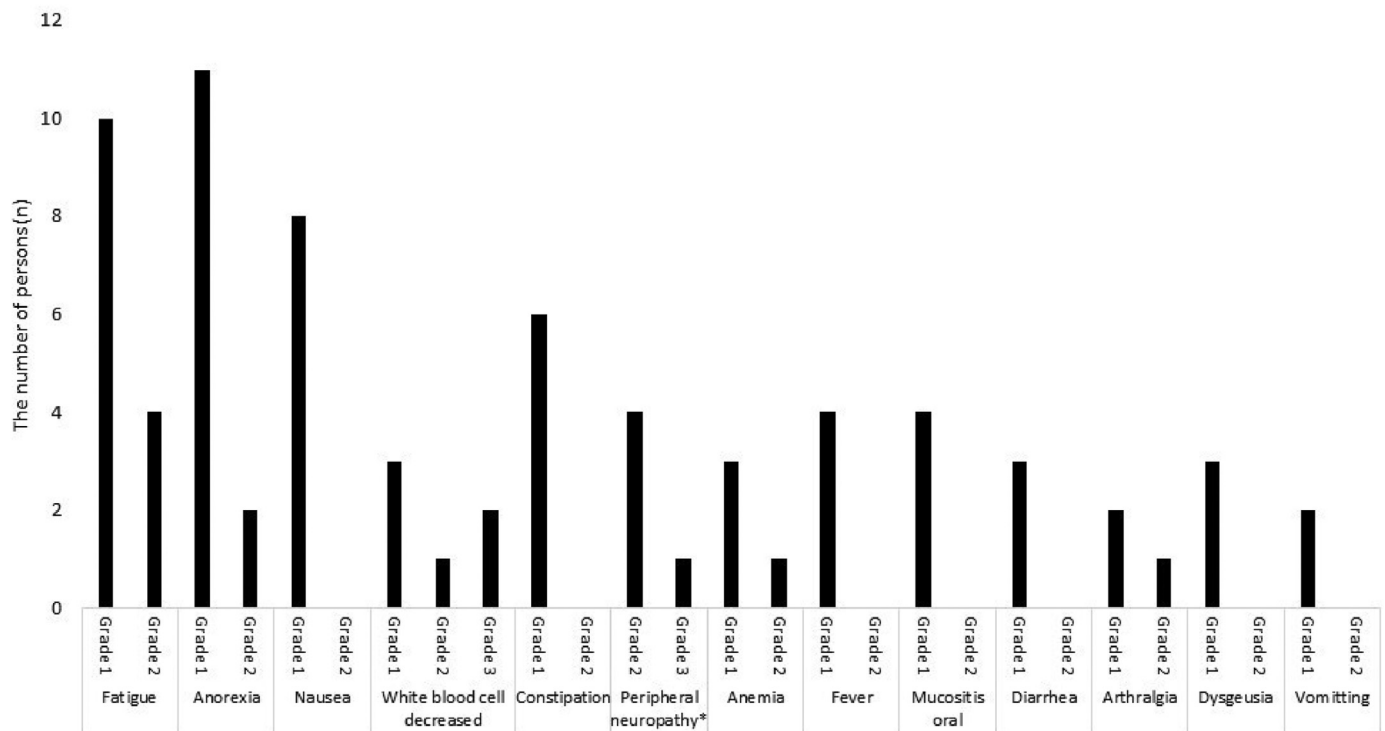


Fig. 1. Occurrence of chemotherapy side effects using Common Terminology Criteria for Adverse Events (CTCAE). \*CTCAE version 5.0 defines no symptoms of peripheral neuropathy as Grade 1.

were stronger than expected and when their blood glucose levels were higher after receiving anticancer drugs than those recorded previously.

This category consists of the concepts <Unsettling feelings about unexpected side effects> and <Fear of blood glucose level elevation>.

*I felt very bad and could not help wondering why I felt so bad. I did not know what I wanted to eat or cook. Now I remember it [the first treatment] as virtual hell for a day. E.*

*I had heard about it [elevation of blood glucose level]; however, it surprisingly became as high as 300. I felt it should be about 200 at most. I felt fear when I saw that it was 300. O.*

**‘Struggle with side effects while paying attention to blood glucose fluctuations’**

Participants struggled to alleviate symptoms while paying attention to the possibility of sudden blood glucose level fluctuations due to diabetes; patients wondering if they could cope with both the blood glucose fluctuations and the side effects they experienced for the first time.

This category consists of the concepts <Struggling alone with painful symptoms>, <Preparing for hypoglycemia effects>, <Identifying blood glucose abnormalities>, and <Negotiation with healthcare providers>.

*There were times when it was really hard on my body. Thinking it [my blood glucose level] was really high, I checked it. However, it was not the blood glucose level that made me feel sick. I laid down thinking that there may have been another reason. After a while, I got up again and repeated the process. I conducted my household affairs little by little. I cannot do everything at once. A.*

**‘Simplification of convalescence based on the diabetes experience’**

When it was difficult for participants to continue their diet and exercise regimen owing to side effects such as fatigue, they tried to continue the regimen in a simplified manner based on their knowledge of diabetes.

This category consists of the concepts <Using simple and quick food recipes> and <Opting for easier exercise regimens>.

*I need to eat a lot of vegetables, but I cannot cook because it is too hard. If I cook hotpot meals, I can eat a lot of vegetables, tofu, and meat. A.*

**‘Trial and error to cope with side effects’**

The participants tried, repeatedly and unsuccessfully, to find better ways to reduce the side effects of the treatment and delay the progress of symptoms.

This category consists of the concepts <Taking measures against side effects before they appear>, <Attempts to alleviate symptoms>, and <Determining when to seek help>.

*I wrapped my fingers with bandages [to prevent the peripheral neuropathy from worsening], thinking it would prevent the drugs from reaching my fingers. However, if I put the bandage on early, my fingers become painful; their color [of the fingers] changes, and they hurt. If I wrap them up to the fingertips, I cannot measure my blood glucose level [this participant learned from the failure and sought assistance from someone]. C.*

**‘Understanding the changes in blood glucose fluctuations and the pattern of physical recovery’**

Participants gradually began to understand the changes in blood glucose fluctuations and their physical recovery pattern by speculating when blood glucose levels would rise and start to fall after receiving anticancer drugs.

This category consists of the concepts <Assessing the effects of blood glucose levels>, <Predicting the pattern of side effect fluctuations>, and <Estimating the timing of a decrease in blood glucose levels>.

*On the days the medication [anticancer drugs] was administered, my blood glucose level sometimes exceeded 200 [mg/dL]. However, it never exceeded 200 at noon the next day, so I just measured [blood glucose level]. F.*

*After I managed to make it through the first week, the conditions just gradually returned to normal. The joint pains also got better. The anorexia and other symptoms like pain gradually disappeared. D.*

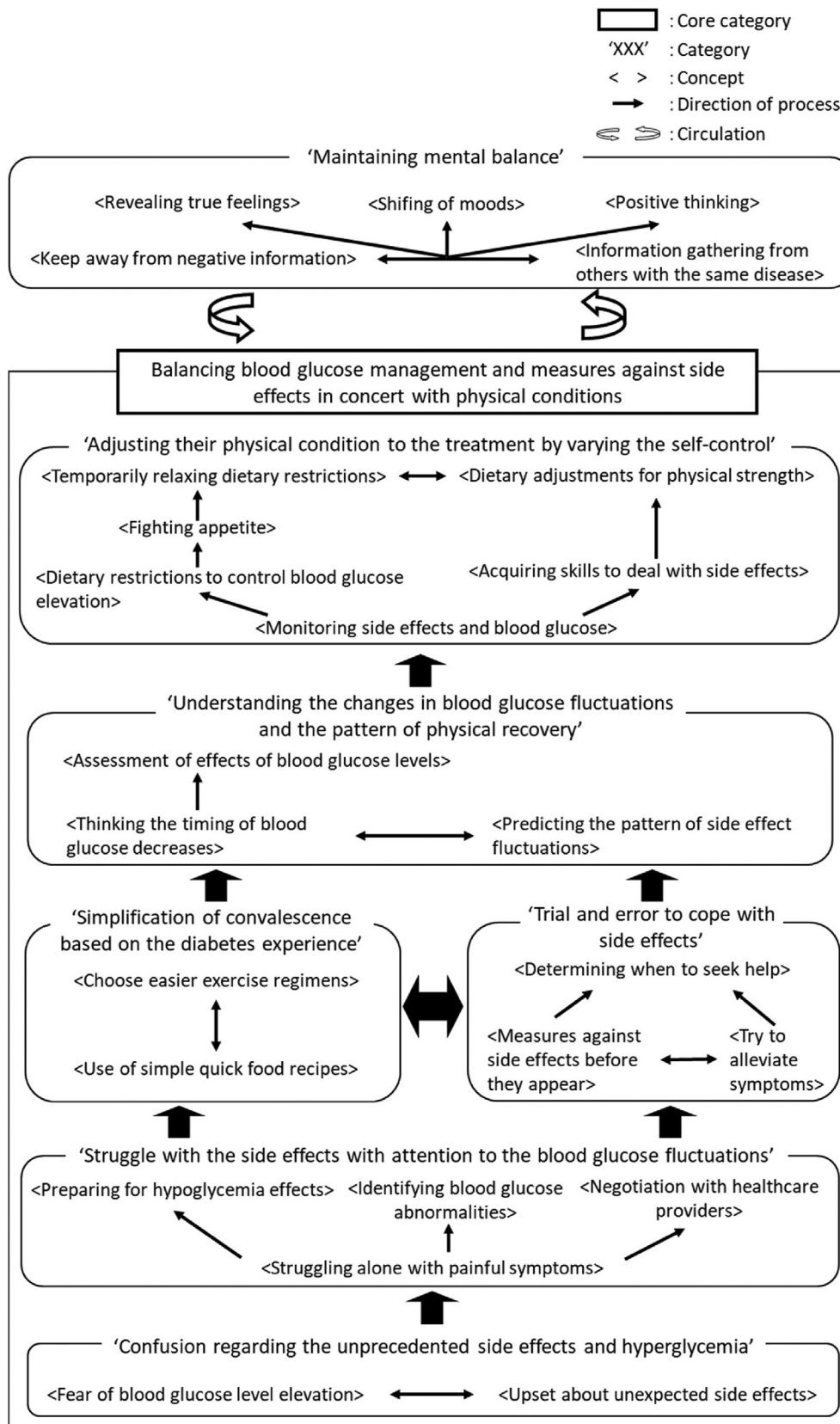


Fig. 2. Result diagram illustrating the storylines.

**Table 2**  
Concept list.

Category	Concept	Definition of concept
Confusion regarding the side effects and hyperglycemia they have not experienced previously	Unsettling feelings about the unexpected side effects of chemotherapy	Getting anxious about side effects that are stronger or more prolonged than expected, without knowing how to cope with them.
	Elevation of blood glucose level	When patients experienced an abnormal elevation of blood glucose levels they have not previously experienced after receiving anticancer drugs, they worry that their blood glucose levels will become even higher.
Struggle with side effects while paying attention to blood glucose fluctuations	Struggling alone with painful symptoms	Immediately make efforts alone to alleviate painful physical symptoms when experienced.
	Preparing for hypoglycemia effects	In cases of the development of hypoglycemia that has not been experienced previously, patients determine methods to cope with it on their own.
	Identifying blood glucose abnormalities	Explore factors that may cause poor health, wondering if high or low blood glucose levels may be the cause of emerging symptoms.
Simplification of convalescence based on the diabetes experience	Negotiation with healthcare providers	Assess if new problems can be handled alone and, if not, discuss the problems with healthcare providers and try to obtain relief.
	Use of simple and quick food recipes	When fatigued, try to come up with and prepare dishes that are easy to cook and unlikely to raise blood glucose level.
	Opting for easier exercise regimens	Change the type and duration of exercises that suit your physical conditions and can be continued despite feeling fatigued owing to chemotherapy.
Trial and error to cope with side effects	Taking measures against side effects before they appear	Adopt measures to minimize the severity of side effects, using knowledge and experience with anticancer medications.
	Attempts to alleviate symptoms	Try methods to alleviate side effects in an individual manner.
	Determining when to seek help	Decide when it is appropriate to ask healthcare providers for help regarding difficulties with the alleviation and prevention of worsening symptoms.
Understanding the changes in blood glucose fluctuations and the pattern of physical recovery	Assessment of the effects of blood glucose levels	Evaluate whether food to be consumed will lead to elevation of blood glucose level and decide whether to eat it.
	Predicting the pattern of side effect fluctuations	Estimate when side effects become more or less severe after receiving anticancer drugs through experience with repeated anticancer drug administrations.

**Table 2 (continued)**

Category	Concept	Definition of concept
Adjusting their physical condition to the treatment by varying self-control	Estimating the timing of decrease in blood glucose level	In advance, estimate when blood glucose levels decrease after anticancer drug administrations.
	Monitoring side effects and blood glucose level	Observe physical status objectively by checking whether there are any changes in your physical condition and measuring blood glucose levels to ensure that there are no changes in your physical condition after receiving anticancer drugs.
	Dietary restrictions to control elevation of blood glucose level	Avoid hyperglycemia by reducing the amount of food consumed or changing to foods that will not significantly elevate blood glucose level.
	Acquiring skills to deal with side effects	Learn ways to minimize the impact of side effects on daily living, even when they are difficult to alleviate.
	Fighting appetite	When feeling hungry, try to overcome the temptation to eat to avoid the impact of elevated blood glucose level on chemotherapy.
	Temporarily relaxing dietary restrictions	Praise yourself for observing dietary restrictions more strictly than before in preparation for chemotherapy and relax your own dietary restrictions from time to time.
Maintaining mental balance	Dietary adjustments for physical strength	Adjust the amount and content of meals with the aim of maintaining your physical condition to endure the effects of receiving anticancer drugs as scheduled, when necessary.
	Gathering information from others with the same disease	Gather information from others with the same disease to obtain a sense of security and confirm that other patients also experience the symptoms and signs you experienced after receiving anticancer drugs, while remembering that there are individual differences in symptoms.
	Staying away from negative information	Intentionally avoid information that is likely to increase anxiety regarding the disease and treatment.
	Positive thinking	Interpret conditions in a positive way when you experience side effects that cannot be effectively treated.
Revealing true feelings	Shifting of moods	Try to cope with feelings of depression caused by the cancer diagnosis and the decision to undergo chemotherapy by concentrating on work and making time to be alone or avoiding being alone.
	Revealing true feelings	Confide thoughts and feelings by complaining and talking about anxieties.

#### *'Adjusting their physical condition to the treatment by varying self-control'*

Participants acquired skills to stabilize blood glucose levels and successfully control side effects and prepared their physical condition to tolerate chemotherapy, aiming to complete the regimen as scheduled.

This category consists of the concepts <Monitoring side effects and blood glucose level>, <Dietary restrictions to control the elevation of blood glucose levels>, <Acquiring skills to deal with side effects>, <Fighting appetite>, <Temporarily relaxing dietary restrictions>, and <Dietary adjustments for physical strength>.

*In the second or third week, I sometimes developed an appetite. On such occasions, I asked myself whether I moved around enough to have [an appetite] at that time. I mean I looked back on whether I used physical energy for work. If I made five round trips between the first and second floors on the day, I said to myself, "I can eat enough to replace the consumed energy." I adjusted the amount of food I ate accordingly. F.*

#### *'Maintaining mental balance'*

Participants tried to maintain their emotional balance in different ways by classifying the information they obtained and changing their moods because they were disheartened upon being diagnosed with cancer and anxious regarding chemotherapy, their response to the treatment, and the various physical symptoms they experienced for the first time.

This category consists of the concepts <Gathering information from others with the same disease>, <Staying away from negative information>, <Positive thinking>, <Shifting of moods>, and <Revealing true feelings>.

*I tried not to browse the [inter]net again and again, thinking that there would rarely be very useful information. If I started browsing, there would be no end to it. K.*

*When I go to work I feel better, as expected. I feel a little different. Time passes and I do not snack while I am on duty. N.*

## Discussion

The results of this study indicated that patients with diabetes, who were diagnosed with cancer and were undergoing chemotherapy, self-managed their conditions by "balancing the management of blood glucose levels and chemotherapy-related side effects according to their physical conditions."

Healthcare providers who specialize in the treatment of cancer or diabetes are aware of the challenges related to balancing glycemic control and cancer treatment. Thus, they focus on cancer treatment because most patients with diabetes undergoing chemotherapy experience a feeling of fear regarding their cancer,<sup>32</sup> whereas some lack awareness regarding their diabetes.<sup>33</sup>

Patients and healthcare providers have a different understanding of self-management of blood glucose levels and side effects due to chemotherapy. This is important because healthcare providers play a significant role in helping patients manage their blood glucose levels and side effects effectively and successfully. The participants in the present study were bewildered by the unexpectedly high blood glucose levels and strong side effects they experienced when they started chemotherapy. They adopted certain coping methods through trial and error while struggling, <Struggling alone with painful symptoms>, to determine effective methods to resolve the abovementioned problems.

Some of the participants recorded blood glucose levels of 250 mg/dL or higher after receiving anticancer drugs, a finding that is similar to those of previous studies.<sup>8,34</sup> The effects of self-management of diabetes before chemotherapy do not affect the level of expertise shown during chemotherapy.<sup>35</sup> The fact that the participants utilized 'trial and error to cope with side effects' suggests that the instructions provided by nurses regarding methods to cope with the side effects of chemotherapy were

inadequate. Oncology nurses tend to provide only general information to patients with diabetes when instructing them on how to deal with the side effects of chemotherapy.<sup>36</sup> It is essential for healthcare providers to provide detailed information and self-management instructions to these patients on how to handle the fluctuations in blood glucose levels that occur after receiving anticancer drugs, the extent of the possible side effects, and how to cope with them. These instructions should be provided early in the pretreatment stage.

Meanwhile, for blood glucose fluctuations, the participants were using 'Simplification of convalescence based on the diabetes experience.' Therefore, it is inferred that the participants were willing to minimize blood glucose fluctuations during chemotherapy and continued blood glucose management by <Using simple and quick food recipes> and <Opting for easier exercise regimens> according to their physical condition. Therefore, healthcare providers are required to provide information on foods, cooking methods, and exercise techniques for patients to continue their diet and exercise regimen in accordance with their physical condition after chemotherapy.

Furthermore, the concept of <Fighting appetite> reveals that maintaining a diet with low blood glucose elevation during the months of chemotherapy can be very stressful for participants. Continuation of this diet is challenging because of the influence of environmental factors, such as the presence of sweet foods, and interpersonal factors, such as the desire to maintain relationships with others.<sup>36</sup> In addition, because steroids have an appetite-enhancing effect,<sup>37</sup> it is anticipated that diet therapy administered during chemotherapy will be more difficult and stressful for patients than that administered before chemotherapy. Participants were able to <Temporarily relax dietary restrictions> and make <Dietary adjustments for physical strength> by understanding the patterns of blood glucose fluctuations and physical recovery after chemotherapy.

The participants in the present study acquired self-monitoring skills while repeatedly receiving anticancer drugs, as illustrated by the category 'understanding the changes in blood glucose fluctuations and the pattern of physical recovery.' Thereafter, the participants may have advanced to the stage of 'adjusting their physical condition to the treatment by exercising self-control in various steps' using the self-monitoring skills they learned experientially. The acquisition of self-monitoring skills is effective in maintaining the motivation to continue treatment and improve lifestyle habits.<sup>38,39</sup> In addition, self-monitoring enables patients to flexibly choose self-management methods to suit their goals and lifestyles.<sup>40,41</sup> Therefore, the acquisition of self-monitoring skills will be a turning point for patients with diabetes with cancer, facilitating flexible management of blood glucose levels and the side effects of chemotherapy.

The participants were confused by the unexpected elevated blood glucose levels and the appearance of side effects after chemotherapy and were anxious about the threat of cancer and the unknown side effects. However, the participants in the present study engaged in self-management by 'maintaining mental balance' while dealing with the threat of cancer and anxiety about the unknown side effects of cancer treatment. Thus, it is apparent that assisting patients in completing chemotherapy while maintaining mental stability and peace of mind is essential.

Based on the study results, it may be necessary to develop a program to promote self-management among patients with diabetes who are diagnosed with cancer and are undergoing chemotherapy. In the present study, patients with diabetes who were undergoing chemotherapy for the first time were confused by the hyperglycemia and side effects that they had not experienced prior. They had to endure a trial and error process of coping strategies during self-management. Therefore, it is pertinent to identify the pattern of blood glucose fluctuations and side effects associated with chemotherapy from an early stage and provide support to enable patients to manage their blood glucose levels as well as take measures to prevent side effects depending on their physical condition. In particular, in a study examining diabetic patients undergoing

chemotherapy, diabetes self-management declined 8 weeks after administration of anticancer drugs.<sup>35</sup> Therefore, focused support should be provided before and during the early stages of anticancer drug administration.

#### Limitations and recommendation

This study has some limitations. First, only participants with cancers in specific locations were included. As such, many cancer types were not covered. Thus, there may be some bias in the selection of the locations of the cancers covered in this study. Future studies should expand on the number of cancer types and participants to determine whether the results revealed in this study can be applied to patients with other cancer types. Second, there were large variations in the number of blood glucose level measurements analyzed, and whether side effects were recorded by participants, making it difficult to collect more meaningful quantitative data. In future, studies should examine whether patients with diabetes who undergo chemotherapy are successfully self-managing by referring not only to blood glucose levels as an indicator but also to HbA1c levels, unscheduled medical visits due to sudden hypo- or hyperglycemia, and emergency hospitalizations.

#### Conclusions

Self-management by patients with diabetes undergoing chemotherapy for the first time involves a process of “balancing the management of blood glucose level and side effects according to the patient's physical condition,” while always striving towards ‘maintaining mental balance.’ The findings of the present study show that patients with diabetes undergoing chemotherapy make efforts to achieve self-management of both blood glucose levels and chemotherapy-related side effects, while experiencing confusion about their abnormally high blood glucose levels and the new side effects of their treatment. The study results also demonstrate that it is important for patients to acquire self-monitoring skills that will enable them to understand the patterns of blood glucose fluctuations and the physical recovery process associated with chemotherapy.

#### Declaration of competing interest

None declared.

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#### Ethics statement

The study was approved by the Ethics Review Committee of Osaka Medical and Pharmaceutical University (2925-5) and the Ethics Review Committee of the facilities from where data were collected. The researcher explained the ethical considerations of the study to the participants orally and in writing, including information regarding voluntary participation, freedom to withdraw, protection of personal information, and data management methods. The author affirms that human research participants provided informed consent for publication of the participant variations.

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